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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

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First Named Inventor	: Stephen WALES		
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Customer No.	: 23911		
Title	: Method of Associating a Training Code to a Channelisation Code in a Mobile Telecommunication System		

SUBMISSION OF PRIORITY DOCUMENT UNDER 35 U.S.C. § 119

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

February 6, 2007

Sir:

The benefit of the filing date of prior foreign application No. 9914858.7, filed in Great Britain on June 25, 1999, was claimed herein pursuant to 35 U.S.C. § 119.

In support of said claim, filed herewith is a certified copy of the original foreign application.

Respectfully submitted,

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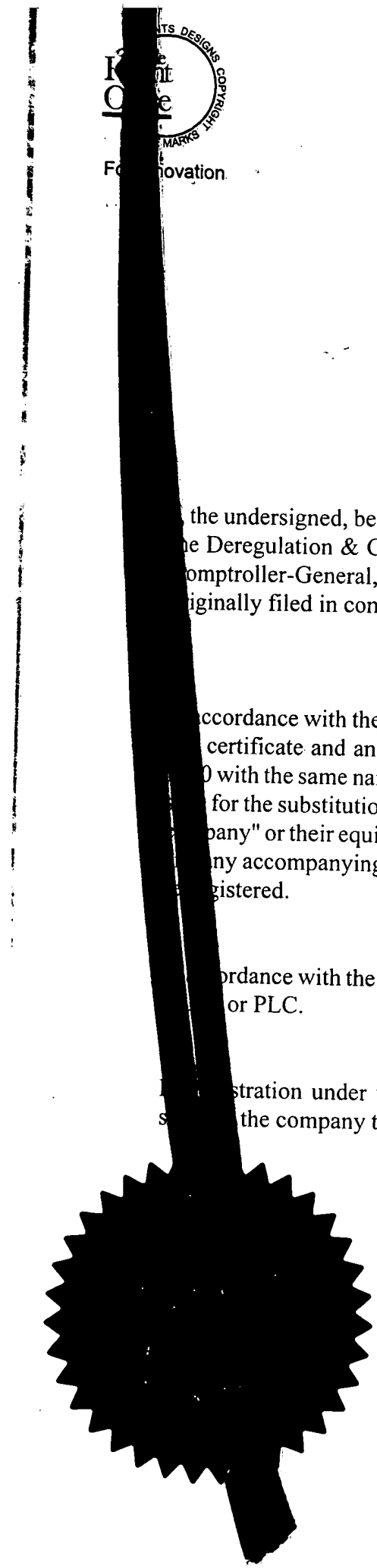

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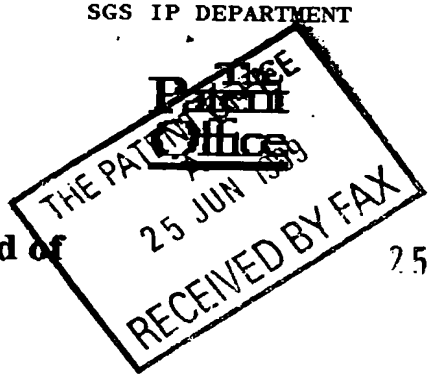

Statement of inventorship and of right to grant of a patent

25 JUN 1999

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Cardiff Road
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1. Your reference
1999P04823/JL/rh

2. Patent application number
(If you know it)
9914858.7

3. Full name of the or of each applicant
Roke Manor Research Limited

4. Title of the invention
IMPROVEMENTS IN OR RELATING TO MOBILE TELECOMMUNICATIONS SYSTEMS

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Signature Date 25/06/99

D ALLEN (Their Attorney)

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D ALLEN - 01344 396808

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   Roke Manor Research Limited
   Roke Manor
   Old Salisbury Lane, Romsey
   Hants SO51 0ZN

   Patents ADP number *(if you know it)*

   If the applicant is a corporate body, give the country/state of its incorporation

   United Kingdom

   S615455002

4. Title of the invention

   IMPROVEMENTS IN OR RELATING TO MOBILE TELECOMMUNICATIONS SYSTEMS

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   Bracknell, Berkshire RG12 8FZ
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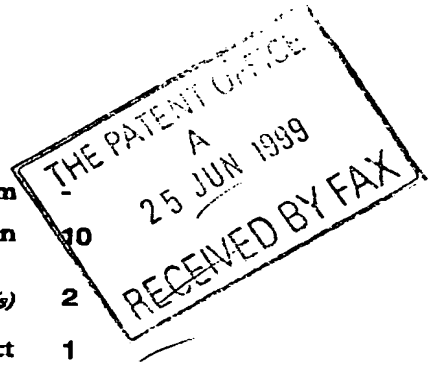

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IMPROVEMENTS IN OR RELATING TO MOBILE TELECOMMUNICATIONS SYSTEMS

The present invention relates to improvements in or relating to mobile telecommunication systems, and is more particularly concerned with such systems operating on code-time division multiple access.

The UMTS terrestrial radio access (UTRA) - time division duplex (TDD) system is based on a combination of code division multiple access (CDMA) and hybrid time division multiple access (TDMA) which is known in the art as code-time division multiple access (CTDMA). (UMTS is an acronym for universal mobile telecommunication system also known by persons skilled in the art.)

In time division multiple access (TDMA), the time axis is divided into a plurality of time slots and users are permitted to transmit in certain ones of those time slots. Code division multiple access (CDMA), on the other hand, utilises direct sequence spread spectrum (DSSS) where a data is multiplied by a spreading factor (Q) prior to transmission in order to encode the data.

Current mobile telecommunications systems comprise a plurality of telecommunication cells each having at least one base station and at least one mobile terminal. Both the base station and the mobile terminal are capable of functioning as a transmitter and a receiver of radio frequency (RF) signals.

In a CTDMA system a number of users are permitted to transmit data sets during the same time slot. Each data set in a given time slot is separated by code division.

In order to receive transmissions in each time slot, the receiver must be able to estimate the characteristics of the transmission channel between the transmitter and receiver. In mobile telecommunications applications multipath distortion can arise and training sequences or some known data content is needed to facilitate channel

estimation in the receiver. The information needed to estimate the transmission channel's characteristics is contained in the channel's impulse response, a term well known in the art. The training sequence may be referred to as a Training code, Midamble code, or Pilot code, all terms well known in the art. For the purposes of the following discussion of the prior art and disclosure of the present invention, the term Training code will be used when referring to the training sequence as defined above.

The Training code is required on both the uplink from mobile terminal to base station and the downlink from the base station to the mobile terminal in order that each transmission path to and from each user can be estimated.

A separate and distinct code from the Training code is the Channelisation code. The Channelisation codes are orthogonal codes taken from the set of Walsh codes and is a term well known in the art. The Channelisation code contains an index number and a spreading factor, both of which serve to encode the data prior to transmission. Thus the Channelisation code is also required during both uplink and downlink in order to interpret a user's data.

To enable multiple spreading factors to be applied to different user's data within the same time slot the Channelisation codes are assigned in a particular way.

The preferred method of assigning Channelisation codes, which is well known in the art, is the Orthogonal Variable Spreading Factor (OVSF) code relationship and is shown in the tree-link structure in Figure 1.

Currently during the downlink, a single Training code is transmitted along with all the data sets of the users in a given time slot. The receiver detects all these data sets along with the single Training code. This is known in the art as Joint Detection and it increases the probability of detecting the data set of interest to a particular mobile terminal user. Having received all the data sets the Receiver must know all the active Channelisation codes in order to insure it is able to interpret the data set of interest.

A problem with the current method is that if the receiver is configured to detect 8 Channelisation codes but only 2 data sets are active, the performance of system will be decreased. Similarly if the receiver is configured to detect 2 Channelisation codes but 6 data sets are active, the performance of the system will be decreased.

Currently, on the uplink of a dedicated channel the base station will know both the Channelisation code and the Training code as it assigns them. The base station communicates these to the mobile terminal in the prior downlink transmission.

However, on the uplink of channels that are not dedicated, for example when the mobile terminal is first switched on, there is often no signalling mechanism to assign Channelisation codes and the mobile terminal will pick at random a Channelisation code to transmit with. Under these circumstances a fixed relationship between the training and Channelisation code must be adopted.

It is therefore an object of the present invention to provide a method of associating a Training code to a Channelisation code in a mobile telecommunications system such that upon detection of the Training code the Channelisation code is known.

According to the present invention there is provided a method of associating a Training code to a Channelisation code for use in a mobile telecommunication system comprising a base station and a mobile terminal, the method comprising the steps of selecting a Channelisation code, encoding data according to the Channelisation code, selecting a Training code based on a predetermined selection process, transmitting the Training code with the data, detecting the Training code and the data, and applying a set of rules to the Training code such that the Channelisation code is known, thereby facilitating interpretation of the data.

According to an aspect of the present invention, wherein the mobile telecommunications system is operating in an uplink mode, the steps include the mobile terminal selecting at random a Channelisation code from a plurality of

available Channelisation codes, the predetermined selection process being such that the Training code selected for transmission to the base station is determined by the Channelisation code selected, and the set of rules applied to the Training code upon detection by the base station being such that for each Training code detected the Channelisation code used to encode the data received with that Training code is known.

According to a further aspect of the present invention, wherein the mobile telecommunications system is operating in a downlink mode, the steps include the base station assigning Training codes to users in a given time slot in a predetermined assignment sequence, the predetermined assignment sequence having a spreading factor associated therewith, and the base station and the mobile terminal having knowledge of the predetermined assignment sequence and associated spreading factor such that upon detection of the Training code by the mobile terminal the Channelisation code used to encode the data is known.

The method according to the present invention may be used in a Code-Division Multiple Access mobile telecommunication system.

Alternatively, the method may be used in a Code-Time Division Multiple Access mobile telecommunications system.

Alternatively, the method may be used in a time division duplex mobile telecommunication system.

Alternatively, the method may be used in a UMTS mobile telecommunications system.

Advantageously, the present invention eliminates the need for explicit transmission of the Training code during uplink mode of operation of a mobile telecommunications system with dedicated channels.

Furthermore, in systems with non-dedicated channels where the mobile terminal selects the Channelisation code at random, the association of the Training code and the Channelisation code is fixed, thus making the detection of data possible.

Advantageously, the present invention improves the performance of a mobile telecommunications system by insuring that the receiver knows the number of Channelisation codes active in a given time slot.

While the principle advantages and features of the invention have been described above, a greater understanding and appreciation of the invention may be obtained by referring to the drawings and detailed description of the preferred embodiment, presented by way of example only, in which;

Figure 1 is a diagram of the known Orthogonal Variable Spreading Factor Channelisation code relationship,

Figure 2 is a diagram, according to the present invention, of the association between Training code and Channelisation code for the Uplink Mode of Operation.

Figure 3 is a diagram, according to the present invention, of the association between Training code and Channelisation code for the Downlink Mode of Operation.

In Figure 1, a known method of depicting Channelisation codes of difference spreading factors is shown in the tree-like structure (10). The available Channelisation codes are denoted by $S_{k,Q}$, where k is the index number and Q is the spreading factor. According to this known method, in order for a Channelisation code to be assigned no other codes of a higher or lower spreading factor along the same branch of the tree on which the code lies can already be assigned.

For example, if $S_{0,4}$ is the code to be assigned, then $S_{0,8}$, $S_{1,8}$, $S_{0,2}$, and $S_{0,1}$ cannot already be assigned.

As was previously stated, both the transmitter and receiver need to know which Training code and which Channelisation code to use. The complexity of the relationship between the Training code and the Channelisation code will depend on

whether the telecommunication system is operating in an downlink mode (base station to mobile terminal) or uplink mode (mobile terminal to base station), and are thus the two modes of operation will be treated separately.

In Figure 2, the association, according to the present invention, between the Training code and the Channelisation code for the uplink mode of operation is showing in tree-like structure (20). As in Figure 1, the available Channelisation codes are denoted by $S_{k,Q}$, where k is the index number and Q is the spreading factor. The available Training codes are denoted by m_j, where j is an integer indicating the maximum number of Training codes available for use in a given time slot. As will be appreciated by those skilled in the art, a plurality of Training codes and a plurality of Channelisation codes may be available.

The association, according to the present invention, between Training codes and Channelisation codes in an uplink mode of operation as shown in Figure 2 will be explained with reference to the following example.

In a preferred embodiment of the present invention a single spreading factor is always used. In the following example of a preferred embodiment of the present invention a spreading factor of 16 is always used. As will be appreciated by those skilled in the art other spreading factors may be used without departing from the scope of the present invention. When a user first switches the mobile terminal on he is operating in an uplink mode on a non dedicated channel. The mobile terminal will select at random a Channelisation code with a spreading factor of 16 in which to use during the first transmission to the base station. Both the base station and the mobile terminal know the association of the codes as shown in Figure 2. Thus once a Channelisation code with a spreading factor of 16 has been randomly selected, the Training code must be the one associated with it as per Figure 2. For example, if the Channelisation code $S_{6,16}$ has been selected, the Training code m_6 must also be used. The data is encoded according to the Channelisation code $S_{6,16}$ and transmitted along

with Training code m_6. The base station then operates to detect the data and the Training code. Upon determining which Training code has been used, the base station will be able to determine which Channelisation code to use based on the association of codes shown in Figure 2. The base station will then be able to interpret the data.

During the downlink mode of operation, the requirements for code association are slightly more complicated. If the mobile terminal is to perform Joint Detection then it needs to know which are the active Channelisation codes and which codes are not active. It is not desirable for this information to be broadcast to all users because of the overhead required. Instead if different Training codes are assigned to each Channelisation code, then a user can easily detect which are the active codes by correlation with the known Training code, rather than attempting to measure the power in all possible codes. However the multiple spreading factors mean that there is a many to one relationship between the Channelisation code and Training code. Adopting a one to one relationship requires the user to correlate with more Training codes. However, if the relationship as shown in Figure 3 is adopted, together with additional rules governing the assignment of Channelisation codes, then the mobile terminal can determine the ambiguity between the Training code and the Channelisation code.

In Figure 3, the association, according to a further aspect of the present invention, between Training codes and Channelisation codes for the downlink mode of operation is shown in tree-like structure (30). The notation used in Figure 3 is the same as used in Figures 1 and 2.

An assignment sequence is used in conjunction with the rules of the OVSF tree shown in Figure 1, such that for a Channelisation code to be used, no other code with a spreading factor greater or smaller than the Channelisation code to be assigned can

also be assigned along the same branch of the tree. A preferred assignment sequence for the association between Training code and Channelisation code is given below:

$Q = 16: \{m_1, m_0, m_5, m_4, \quad m_3, m_2, m_7, m_6\}$

$Q = 8: \{m_6, m_2, \quad m_4, m_0\}$

$Q = 4: \{m_2, \quad m_0\}$

$Q = 2: \{m_0\}$

As will be appreciated by those skilled in the art alternative assignment sequences may be used without departing from the scope of the present invention.

Assignments for a particular spreading factor are made from left to right in the above sequences. Consequently, if the first Channelisation code uses Training code m_1 then subsequent use of Training code m_0 means that it must be associated with a spreading factor of 16, until Training code m_1 is relinquished. Similarly the use of Training code m_0 before Training code m_1 signifies that the spreading factor is 2. The assignment ordering above together with the rules of the OVSF tree means that Channelisation code can be determined, providing that the presence of the Training codes can be reliably detected.

The association, according to the present invention, between Training codes and Channelisation codes in an downlink mode of operation as shown in Figure 3 will be explained with reference to the following example.

After a user has switched on his mobile terminal and established contact with the base station, the base station will then assign that user a Channelisation code and a Training code. However, as will be appreciated by those skilled in the art, in a CDMA or CTDMA system, several users may be operating in the same time slot, all with their own unique Channelisation code and Training code as assigned by the base

station. The base station will transmit simultaneously all the data of the users operating in that given time slot. According to an aspect of the present invention, the base station will only transmit a single Training code with each user's data. Furthermore, the base station will assign Training codes accordingly to the assignment sequence given above. Both the base station and the mobile terminal will know the association of the codes as shown in Figure 3 and the assignment sequence. The mobile terminal operating in Joint Detection will detect all the data and Training codes transmitted by the base station. Based on the order the Training codes are received, the mobile terminal will know which spreading factor has been used to encode the data. Knowing the Training code and the spreading factor allows the mobile terminal to determine the active Channelisation codes by reference to the association of codes shown in Figure 3.

For example, if the Training codes m_6, m_2, m_4, and m_0 are detected by the mobile terminal, then based on the assignment sequence given above, the mobile terminal knows that the spreading factor is 8. Now by referring to association of codes shown in Figure 3, the mobile terminal will known that the Channelisation code $S_{3,8}$, $S_{2,8}$, $S_{1,8}$, and $S_{0,8}$ are active in the time slot and thus be looking for 4 sets of data.

As is well known in the art the Training code is easier to detect because it has a fixed sequence.

As was previously stated, the performance for the system is enhanced when the receiver knows which Channelisation codes are active in a given time slot. The present invention provides a method for doing this.

As will be appreciated by those skilled in the art, the method of associating codes as per the present invention, can be used in a mobile telecommunication system operating in CDMA or CTDMA.

Furthermore, the method according to the present invention can be used in UMTS.

As will be appreciated by those skilled in the art, various modifications may be made to the embodiment hereinbefore described without departing from the scope of the present invention.

CLAIMS

1. A method of associating a Training code to a Channelisation code for use in a mobile telecommunication system comprising a base station and a mobile terminal, the method comprising the steps of:

selecting a Channelisation code,

encoding data according to the Channelisation code,

selecting a Training code based on a predetermined selection process,

transmitting the Training code with the data,

detecting the Training code and the data, and

applying a set of rules to the Training code such that the Channelisation code is known, thereby facilitating interpretation of the data.

2. A method as claimed in Claim 1, wherein the mobile telecommunications system is operating in an uplink mode, and the steps include:

the mobile terminal selecting at random a Channelisation code from a plurality of available Channelisation codes,

the predetermined selection process being such that the Training code selected for transmission to the base station is determined by the Channelisation code selected, and

the set of rules applied to the Training code upon detection by the base station being such that for each Training code detected the Channelisation code used to encode the data received with that Training code is known.

3. A method as claimed in Claim 2, wherein the spreading factor of the randomly selected Channelisation code is 16.

4. A method as claimed in any preceding Claim, wherein the mobile telecommunications system is operating in a downlink mode, and the steps include:

the base station assigning Training codes to users in a given time slot in a predetermined assignment sequence, the predetermined assignment sequence having a spreading factor associated therewith, and

the base station and the mobile terminal having knowledge of the predetermined assignment sequence and associated spreading factor such that upon detection of the Training code by the mobile terminal the Channelisation code used to encode the data is known.

5. A method as claimed in Claim 4, wherein the predetermined assignment sequence is:

for $Q = 16$: $\{m_1, m_0, m_5, m_4, \quad m_3, m_2, m_7, m_6\}$

for $Q = 8$: $\{m_6, m_2, \quad m_4, m_0\}$

for $Q = 4$: $\{m_2, \quad m_0\}$

for $Q = 2$: $\{m_0\}$

where Q equals the spreading factor and m_j represents the available Training codes.

6. A Code-Division Multiple Access mobile telecommunication system using the method as claimed in any of Claims 1 - 5.

7. A Code-Time Division Multiple Access mobile telecommunications system using the method as claimed in any of Claims 1 -5.

8. A time division duplex mobile telecommunication system using the method as claimed in any of Claims 1 - 5.

9. A UMTS mobile telecommunications system using the method as claimed in any of Claims 1 - 5.

10. A method of associating a Training code to a Channelisation code as hereinbefore described with reference to the accompanying drawings.

IMPROVEMENTS IN OR RELATING TO MOBILE TELECOMMUNICATIONS SYSTEMS

ABSTRACT

A method of associating the Training code to a Channelisation code in a mobile telecommunications system. The method includes associating a Training code with a Channelisation code prior to transmission according to a set of rules such that upon detection of the Training code by a receiver, the Channelisation code is known.

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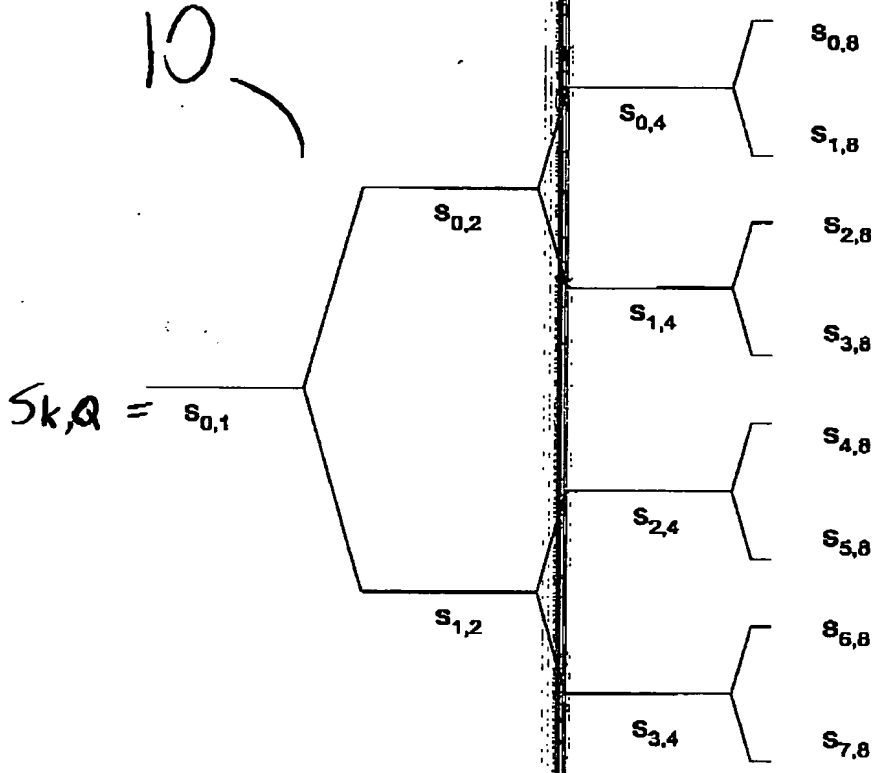

Figure 1 Orthogonal Variable Spreading Factor Channelisation Codes Relationship

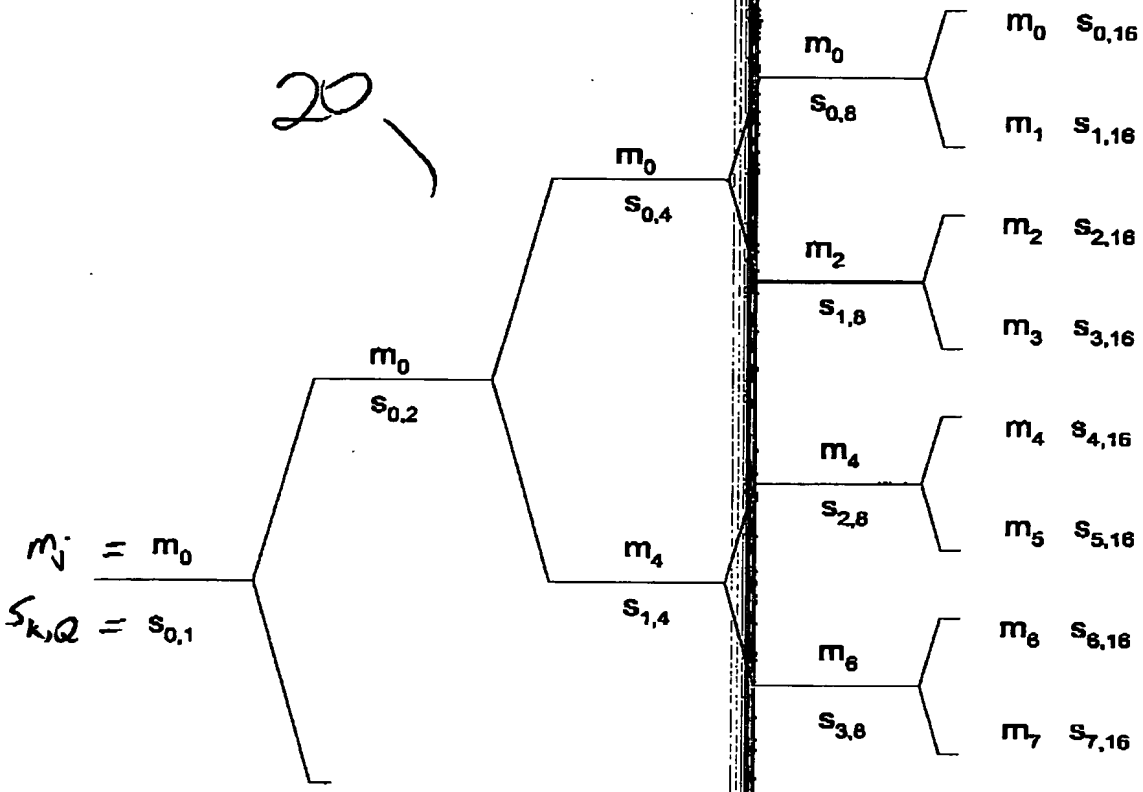

Figure 2 Association Between Training Code and Channelisation Code for the Uplink

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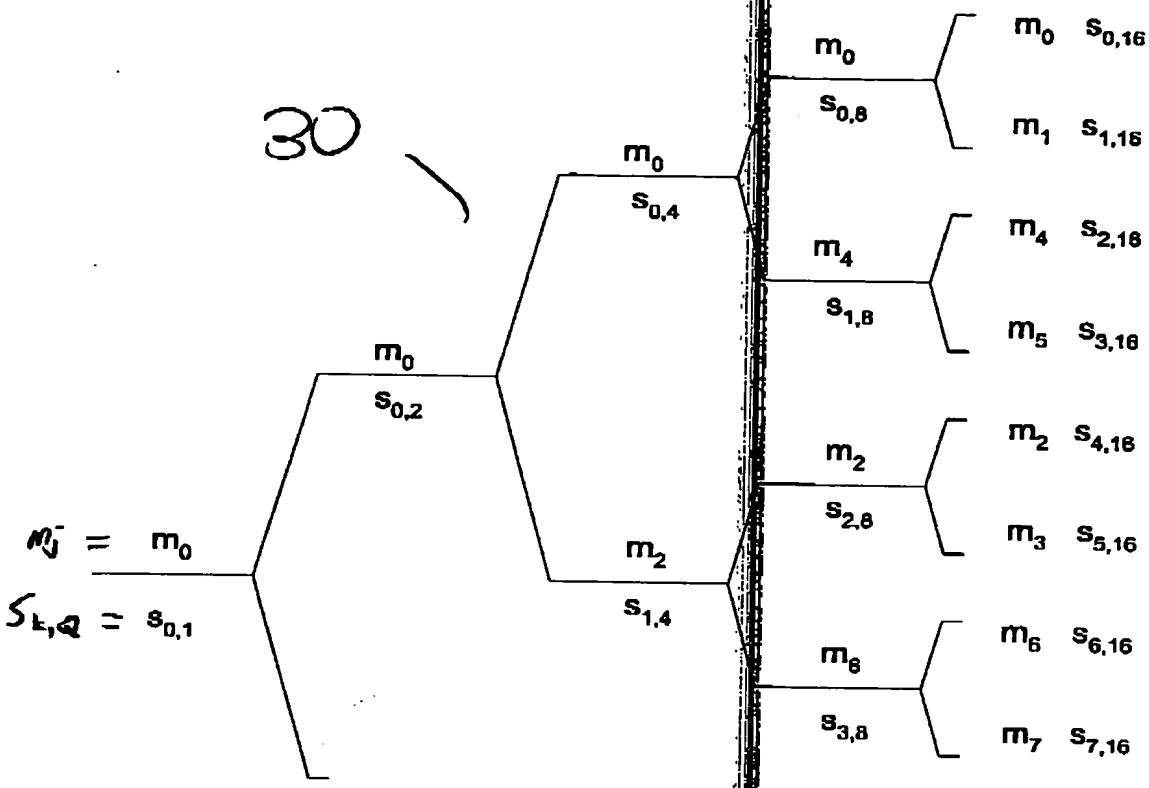

Figure 3 Association Between Training Code and Channelisation Code for the Downlink

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